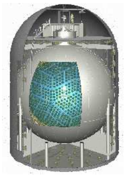
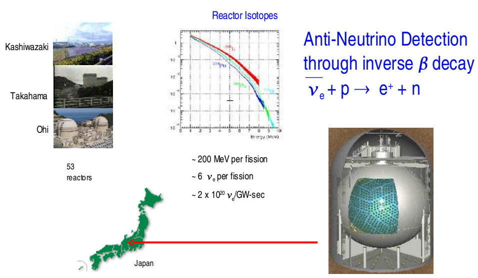


A Full Volume Calibration System for KamLAND

L. Winslow for the KamLAND Collaboration

Physics of KamLAND

KamLAND measures the number of anti-neutrinos produced by the nuclear reactors of Japan.

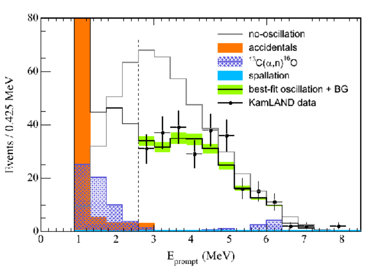


The spectrum of $\bar{\nu}_e$ detected depends on the initial reactor spectrum for each of the reactors, the distance to the reactors, the cross section for inverse beta decay, and the number of protons contained in the fiducial volume. If $\bar{\nu}_e$ oscillate into $\bar{\nu}_\mu$ or $\bar{\nu}_\tau$, KamLAND will detect a deficit of $\bar{\nu}_e$ consistent with the survival probability. The $\bar{\nu}_e$ survival probability is given by:

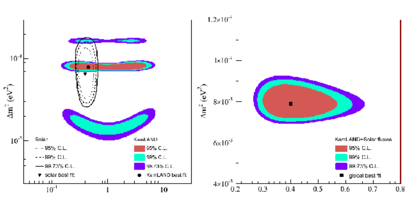
$$P(\bar{\nu}_e \rightarrow \bar{\nu}_e) = 1 - \sin^2(2\theta)\sin^2(1.27(\delta m^2)\frac{L}{E})$$

KamLAND Results

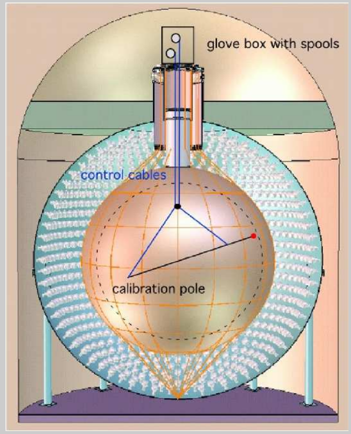
We observed a deficit of electron anti-neutrinos and a distortion of the energy spectrum consistent with neutrino oscillations.



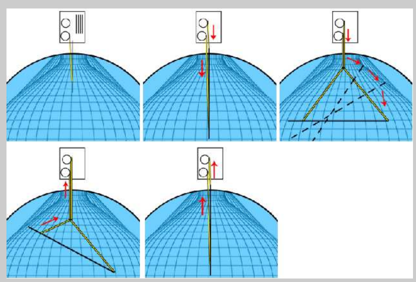
Using this data you can fit for the oscillation parameters for the KamLAND data and the data combined with other neutrino experiments.



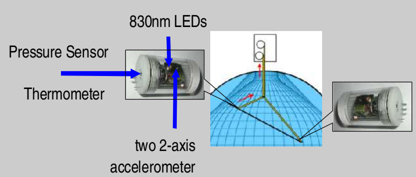
KamLAND Only Contours KamLAND + Solar Data Contours



The pole is broken into 3ft pieces that are assembled and slowly lowered into the detector before unfolding in the horizontal position.

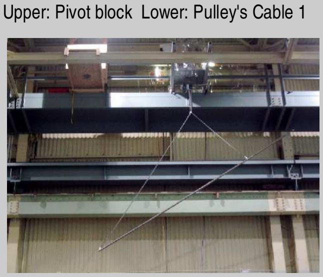


Instrumentation of the Pole



Method	Instrument	Error
Cable Length	(encoder pulleys)	0.5cm
Depth	(2 pressure sensors plus reference)	1cm
Inclination	(Accelerometers)	1 degree
CCD Imaging	(all cameras operational)	5cm

Upper: Pivot block Lower: Pulley's Cable 1



Testing the Pole

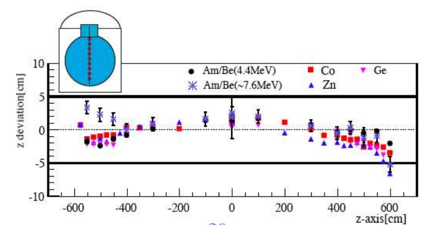
Measurement Uncertainties

Fiducial Volume	4.70%
Energy Threshold	2.30%
Efficiency of Cuts	1.60%
Livetime	0.06%
Reactor Power	2.10%
Fuel Composition	1.00%
Anti-neutrino Spectra	2.50%
Cross Section	0.20%
Total	6.50%

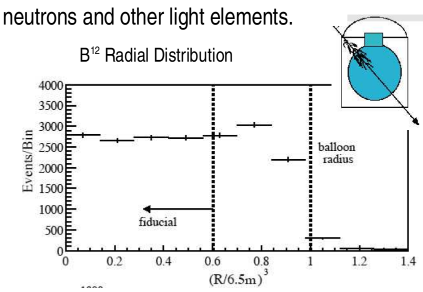
The uncertainties highlighted in blue are from the data provided by the electric companies that maintain the nuclear reactors or from theoretical calculations. The uncertainties in red are from our knowledge of where an event of energy $E_{visible}$ is reconstructed in the detector.

Calibrating Position and Energy

Currently we can deploy several different radioactive source along the z-axis and compare the known position and energy to that reconstructed from the data.



We can also use events that are known to be isotropically distributed through out the detector to determine the uncertainty in radius . These events are most often muon spallation products like neutrons and other light elements.

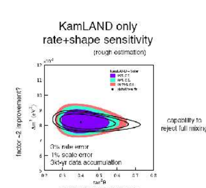


What if we could calibrate better?

Fiducial volume: R < 5.5 m

R_{FV} = 5 cm V= 2.7%

R_{FV} = 2 cm V= 1.1%



For more information on KamLAND http:kamland.lbl.gov

Installation Fall 2005!